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Oskarshamn site investigation

Drill hole KAV04A

Determining of porosity by water saturation and density by buoyancy technique

M Savukoski
SP Swedish National Testing and Research Institute

October 2004

Svensk Kärnbränslehantering AB

Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19



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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author and do not necessarily coincide with those of the client.

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Abstract

The density and porosity has been determined on 10 specimens (each divided in two pieces) from drill hole KAV04A. The specimens were sampled on one level in the drill hole at approximately 500 m. The investigated rock types are mapped as Ävrö granite and Quartz monzodiorite. The results for dry density varied between 2,670 and 2,910 kg/m³, for wet density the results varied between 2,670 and 2,910 kg/m³ and the results for porosity varied between 0.2 and 0.6%.

Sammanfattning

Densiteten och porositeten har bestämts på 10 provkroppar (varje provkropp delad i två delar) från borrhål KAV04A. Proverna togs från en nivå i borrhålet vid ca 500 m. De undersökta bergartstyperna är karterad som Ävrögranit och Kvarts monzodiorite. Resultaten för den torra densiteten varierade mellan 2 670 och 2 910 kg/m³, för den våta densiteten varierade resultaten mellan 2 670 och 2 910 kg/m³ och resultaten för porositeten varierade mellan 0,2 och 0,6%.

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1 Introduction

The purpose is to determine the porosity and the wet and dry density of the samples.

The cores are sampled from borehole KAV04A in the Simpevarp area. Thomas Jansson, Tyréns AB, and Urban Åkesson, Swedish National Testing and Research Institute (SP) sampled them 14 June 2004. Specimens were taken from one level in the rock core at level 1 between 492 and 522 m. The samples were selected based on the preliminary core logging, and with the strategy to primarily investigate the properties of the dominant rock. The rock cores were transported from Simpevarp and arrived to SP in August. The testing was started in September 2004 and ended in October 2004.

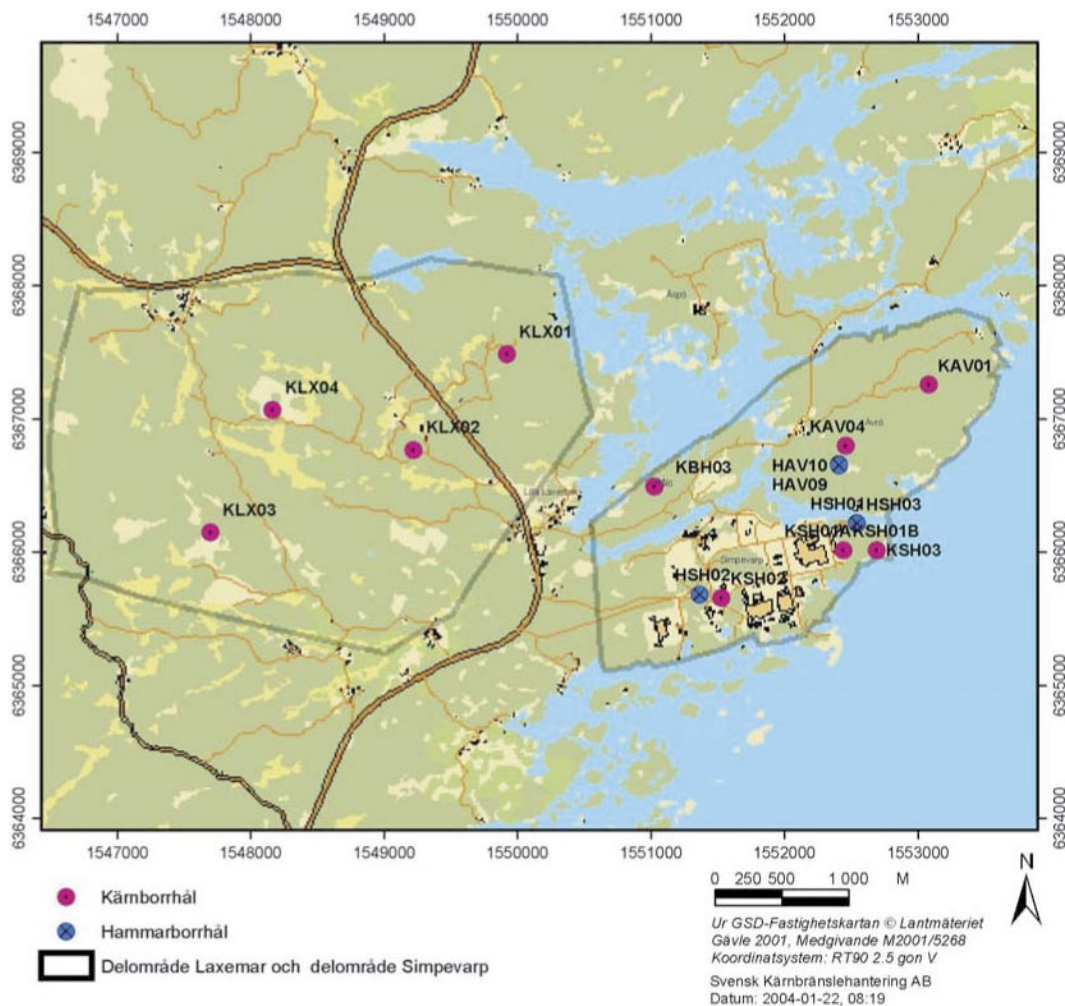


Figure 1-1. Location of the drill hole KAV04A at the Simpevarp site.

2 Objective and scope

The purpose of the testing is to determine the density and porosity of intact rock core. The parameters are used in the rock mechanics and thermal site descriptive model, which will be established for the candidate area selected for site investigations at Simpevarp.

The samples are from the borehole KAV04A in Simpevarp, which is a telescope borehole of SKB-standard type with a borehole depth of 1,000 m. The samples in this report are taken at one main level.

3 Equipment

Following equipment have been used for the analyses:

- Thermometer (inv no 100877) for measurement of water temperature. Calibrated 2004-03-11. Uncertainty of measurement $\pm 0,4^{\circ}\text{C}$.
- Scale (inv no 102291) for weight measurement. Calibrated in March 2004. Uncertainty of measurement $\pm 0,2\text{g}$.
- Heating chamber (inv no 102289) for drying the specimens. Calibrated 2004-08-31. Uncertainty of measurement $\pm 5^{\circ}\text{C}$.
- A covered plastic box filled with water for water saturation of the samples.
- A dessicator for cooling samples in.

Uncertainty of method as expanded uncertainty with covering factor 2 (95% confidence interval):

Density $\pm 4 \text{ kg/m}^3$

Porosity $\pm 0,09\%$

Waterabsorption $\pm 0,05\%$

4 Execution

Determination of the porosity and density was made in accordance with SKB's method description SKB MD 160.002e-version 2.0 (SKB internal controlling document); This includes determination of density in accordance to /ISRM, 1979/, volume 16, number 2, water saturation by /EN 13755/ and in accordance to Activity plan AP PS 400-04-074 (internal controlling document of SKB). The Department of Building Technology and Mechanics (BM) at SP performed the test.

4.1 Description of the samples

From the Simpevarp area specimens were sampled from one level in drill hole KAV04A. Level 1 ranged between 492 and 522 m. Table 4-1 show the rock type and identification marks of the specimens.

Table 4-1. Rock type and identification marks (Rock-type classification according to Boremap).

Identification	Sampling depth (Seclow)	Rock type
KAV04A-90V-1	492.31	Quartz monzodiorite
KAV04A-90V-2	492.38	Quartz monzodiorite
KAV04A-90V-3	495.01	Quartz monzodiorite
KAV04A-90V-4	495.08	Quartz monzodiorite
KAV04A-90V-5	495.15	Quartz monzodiorite
KAV04A-90V-7	521.52	Ävrö granite
KAV04A-90V-8	521.59	Ävrö granite
KAV04A-90V-9	521.66	Ävrö granite
KAV04A-90V-10	521.73	Ävrö granite
KAV04A-90V-11	521.80	Ävrö granite

4.2 Testing

The execution procedure followed the prescription in SKB MD 160.002e-version 2.0 (SKB internal controlling document) and the following steps were performed, see Table 4-2:

Table 4-2.

Activity no	Activity
1	The specimens were cut according to the marks on the rock cores. Every specimen was cut in two pieces, marked A and B and about 25 mm thick each. The same specimens were used to test Thermal properties: heat conductivity and heat capacity determining using the TPS method.
2	The specimens were photographed in JPEG-format.
3	The specimens were water saturated in normal air pressure for at least seven days.
4	The specimens were weighted in tapwater (See Appendix 2)
5	The specimens were surface dried with a towel and weighted.
6	The water saturated density was determined (See Appendix 2).
7	The samples were sent from SP Building and Mechanics to SP Fire Technology for measurement of thermal properties.
8	The samples were sent back from SP Fire Technology to SP Building and Mechanics
9	The specimens were dried in a heating chamber at 105°C.
10	The specimens were transported to a dessicator for cooling.
11	The dry density and porosity was determined (See Appendix 2).

5 Results

The main results of the site investigation of KAV04A could be found in the database SICADA FN428. The data from SICADA should be used for modelling.

Protocols, calculations and pictures can be found in Appendix 1–2.

5.1 Description and presentation of the specimen

The temperature of water for water saturation was 18,5°C and the density of the water was 999 kg/m³. The specimens were dried in 105° C for one week after water saturation. Table 5-1, 5-2 and 5-3 shows the results for the different levels.

Table 5-1. Summary of the results for porosity, dry density and wet density of the specimens from level 1, seclow 492 to 522 m. The result for each specimen is a mean value of subsample A and B.

Specimen	Sampling depth, according to the marks on the drill-core boxes (Seclow) (m)	Porosity (%)	Dry density (kg/m ³)	Wet density (kg/m ³)
KAV04A-90V-1	492.31	0.3	2,900	2,900
KAV04A-90V-2	492.38	0.2	2,910	2,910
KAV04A-90V-3	495.01	0.3	2,870	2,880
KAV04A-90V-4	495.08	0.3	2,880	2,880
KAV04A-90V-5	495.15	0.3	2,870	2,880
KAV04A-90V-7	521.52	0.6	2,690	2,690
KAV04A-90V-8	521.59	0.6	2,690	2,690
KAV04A-90V-9	521.66	0.5	2,680	2,690
KAV04A-90V-10	521.73	0.6	2,680	2,680
KAV04A-90V-11	521.80	0.6	2,670	2,670
Mean value		0.4	2,780	2,790
Standard deviation		0.2	11	11

5.2 Results for the entire test series

Results for the entire test series are shown in the diagrams below. They are divided into 3 diagrams, dry density, wet density and porosity, see Figures 5-1, 5-2 and 5-3.

Dry Density KAV04A

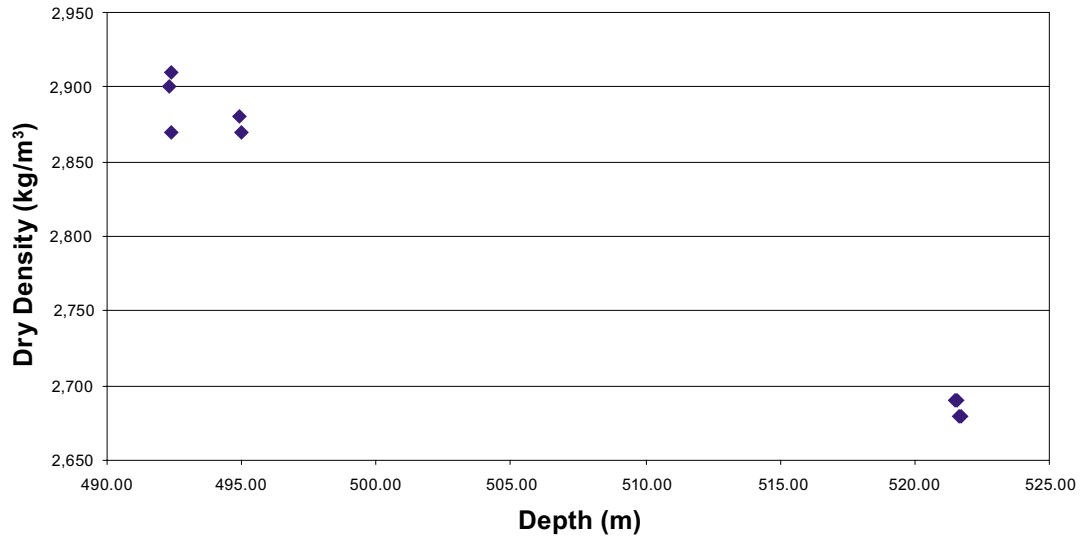


Figure 5-1. Density (dry) versus depth, depth is where the samples are taken in the borehole.

Wet Density KAV04A

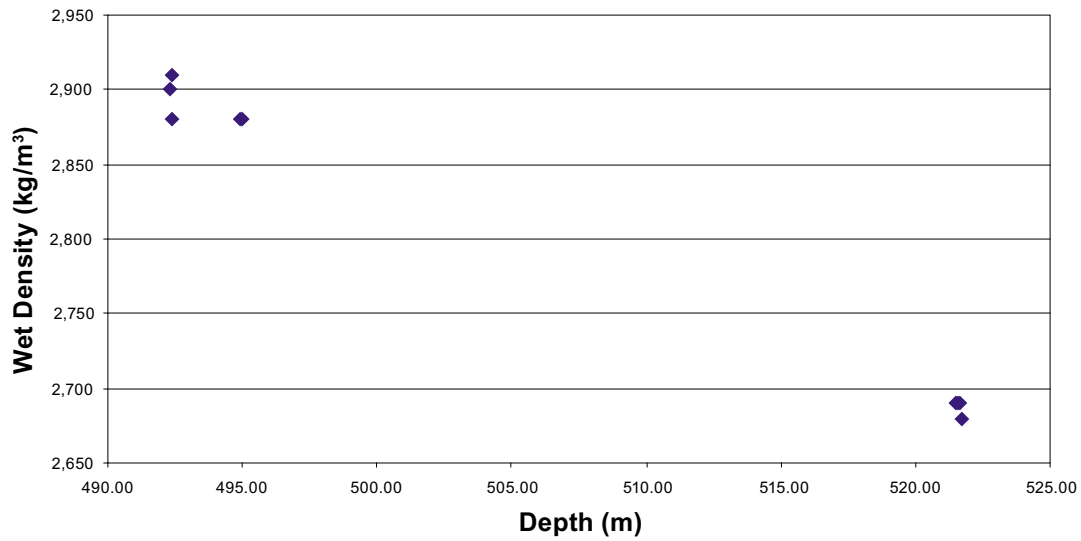


Figure 5-2. Density (wet) versus depth, depth is where the samples are taken in the borehole.

Porosity KAV04A

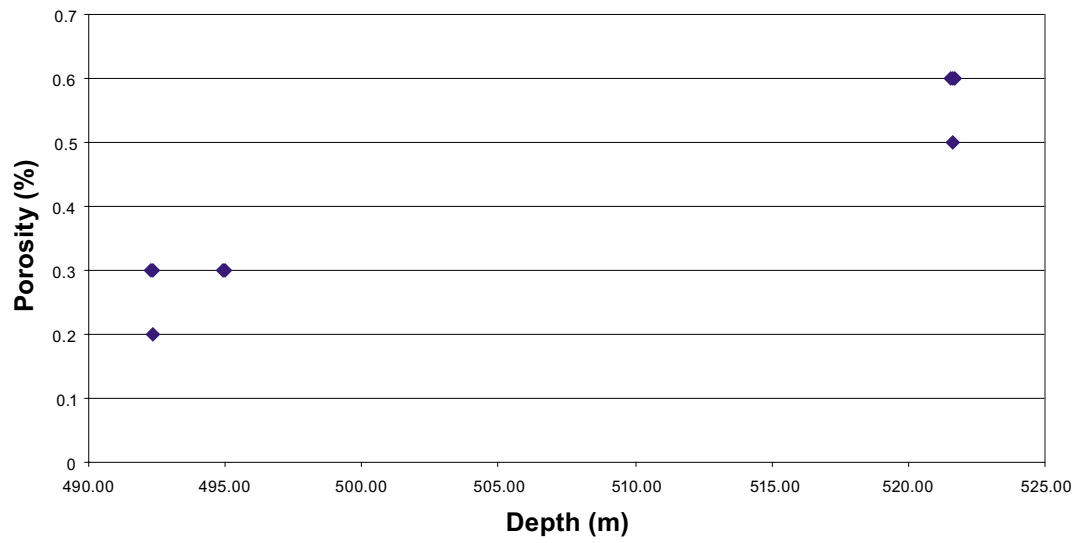


Figure 5-3. Porosity versus depth, depth is where the samples are taken in the borehole.

5.3 Discussion

The tests were performed in accordance with the method descriptions. The activity plan was followed without deviations.

References

ISRM, 1979. Volume 16, Number 2.

EN 13755. Natural stone test methods – Determination of water absorption at atmospheric pressure

Results and pictures

Table 1. Level 1 492–522 m, specimen KAV04A-090V-1 to KAV04A-090V-11.

KAV04A-90V-1 (492.31)

The dry density for specimen KAV04A-90V-1A was measured to be 2,900 kg/m³ and the porosity to 0,2% and the dry density for specimen KAV04A-90V-1B was measured to be 2,900 kg/m³ and the porosity to 0.5%.

Figure 1. Specimen KAV04A-90V-1.



KAV04A-90V-2 (492.38)

The dry density for specimen KAV04A-90V-2A was measured to be 2,910 kg/m³ and the porosity to 0.2% and the dry density for specimen KAV04A-90V-2B was measured to be 2,910 kg/m³ and the porosity to 0.2%.

Figure 2. Specimen KAV04A-90V-2.



KAV04A-90V-3 (495.01)

The dry density for specimen KAV04A-90V-3A was measured to be 2,870 kg/m³ and the porosity to 0.3% and the dry density for specimen KAV04A-90V-3B was measured to be 2,880 kg/m³ and the porosity to 0.3%.

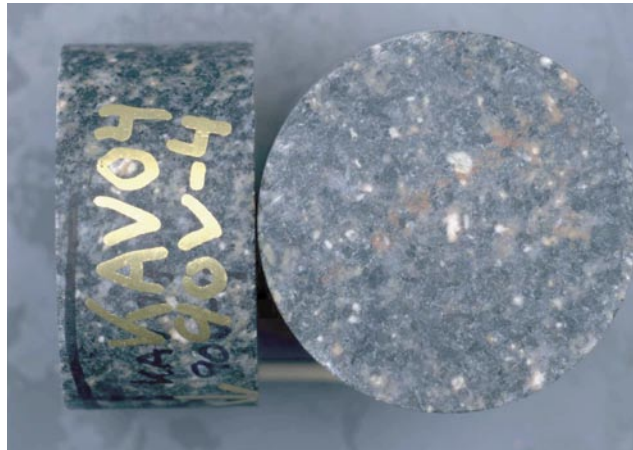
Figure 3. Specimen KAV04A-90V-3.



KAV04A-90V-4 (495.08)

The dry density for specimen KAV04A-90V-4A was measured to be 2,880 kg/m³ and the porosity to 0.3% and the dry density for specimen KAV04A-90V-4B was measured to be 2,880 kg/m³ and the porosity to 0.3%.

Figure 4. Specimen KAV04A-90V-4.



KAV04A-90V-5 (495.15)

The dry density for specimen KAV04A-90V-5A was measured to be 2,870 kg/m³ and the porosity to 0.3% and the dry density for specimen KAV04A-90V-5B was measured to be 2,880 kg/m³ and the porosity to 0.2%.

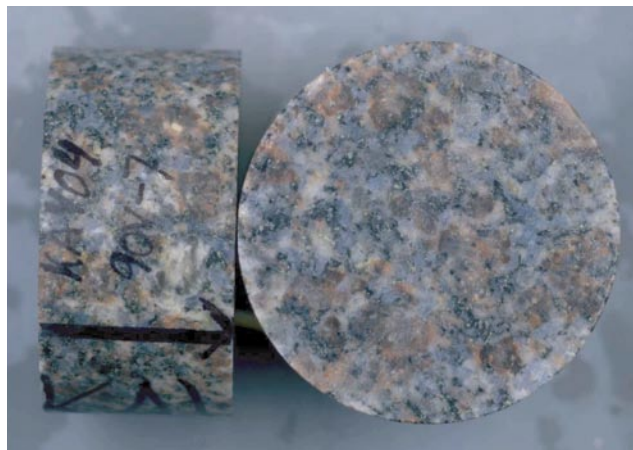
Figure 5. Specimen KAV04A-90V-5.



KAV04A-90V-7 (521.52)

The dry density for specimen KAV04A-90V-7A was measured to be 2,690 kg/m³ and the porosity to 0.6% and the dry density for specimen KAV04A-90V-7B was measured to be 2,680 kg/m³ and the porosity to 0.6%.

Figure 6. Specimen KAV04A-90V-7.



KAV04A-90V-8 (521.59)

The dry density for specimen KAV04A-90V-8A was measured to be $2,690 \text{ kg/m}^3$ and the porosity to 0.5% and the dry density for specimen KAV04A-90V-8B was measured to be $2,680 \text{ kg/m}^3$ and the porosity to 0.6%.

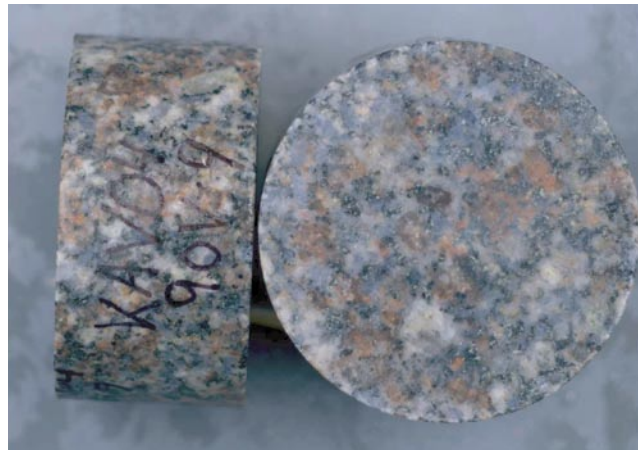
Figure 7. Specimen KAV04A-90V-8.



KAV04A-90V-9 (521.66)

The dry density for specimen KAV04A-90V-9A was measured to be $2,680 \text{ kg/m}^3$ and the porosity to 0.6% and the dry density for specimen KAV04A-90V-9B was measured to be $2,680 \text{ kg/m}^3$ and the porosity to 0.5%.

Figure 8. Specimen KAV04A-90V-9.



KAV04A-90V-10 (521.73)

The dry density for specimen KAV04A-90V-10A was measured to be $2,680 \text{ kg/m}^3$ and the porosity to 0.6% and the dry density for specimen KAV04A-90V-10B was measured to be $2,680 \text{ kg/m}^3$ and the porosity to 0.6%.

Figure 9. Specimen KAV04A-90V-10.



KAV04A-90V-11 (521.80)

The dry density for specimen KAV04A-90V-11A was measured to be $2,670 \text{ kg/m}^3$ and the porosity to 0.6% and the dry density for specimen KAV04A-90V-11B was measured to be $2,670 \text{ kg/m}^3$ and the porosity to 0.6%.

Figure 10. Specimen KAV04A-90V-11.



Calculation of density and porosity

Densitet och porositet, SKB

KAVO4

Vattnets temperatur (°C): 18.5

Vattnets densitet (°C): 0.998

Uppdrags nr: P402276

Metod: /EN 13755; ISRM ,1979/, avsnitt 3 samt SKB MD 160.002 version 2.0

Provad av: Lej

Datum: 2004-09-11–10-05. Till BR 2004-09-13. Åter BMm 2004-10-01.

Våg, inv.nr: 102291

Termometer, inv.nr: 100877

Provmärkning:	Vikt i vatten, Msub (g)	Yttor vikt, Msat (g)	Torr vikt, Ms (g)	Bulk volume, V (cm ³)	Pore volume, Vv (cm ³)	Porosity, n (%)	Porosity, (%)	Dry density, pd (g/cm ³)	Dry density, AB (g/cm ³)	Wet density (g/cm ³)	Wet density AB (g/cm ³)
1 KAVO4-1A	98.74	150.57	150.46	51.91	0.11	0.2	0.3	2.90	2.90	2.90	2.90
2 1B	98.82	150.63	150.39	51.89	0.24	0.5		2.90		2.90	
3 2A	98.95	150.6	150.52	51.73	0.08	0.2	0.2	2.91	2.91	2.91	2.91
4 2B	99.04	150.75	150.64	51.79	0.11	0.2		2.91		2.91	
5 3A	96.8	148.45	148.3	51.73	0.15	0.3	0.3	2.87	2.87	2.87	2.88
6 3B	98.18	150.21	150.07	52.11	0.14	0.3		2.88		2.88	
7 4A	97.9	149.82	149.67	52.00	0.15	0.3	0.3	2.88	2.88	2.88	2.88
8 4B	98.34	150.4	150.26	52.14	0.14	0.3		2.88		2.88	
9 5A	97.43	149.35	149.2	52.00	0.15	0.3	0.3	2.87	2.87	2.87	2.88
10 5B	97.94	149.89	149.78	52.03	0.11	0.2		2.88		2.88	
11 R6A	95.88	147.86	147.72	52.06	0.14	0.3	0.3	2.84	2.85	2.84	2.86
12 R6B	97.5	149.51	149.38	52.09	0.13	0.3		2.87		2.87	
13 7A	86.82	137.91	137.62	51.17	0.29	0.6	0.6	2.69	2.69	2.70	2.69
14 7B	86.86	138.14	137.85	51.36	0.29	0.6		2.68		2.69	
15 8A	87.58	139.11	138.83	51.61	0.28	0.5	0.6	2.69	2.69	2.70	2.69
16 8B	86.8	138.12	137.83	51.40	0.29	0.6		2.68		2.69	
17 9A	86.11	137.15	136.86	51.12	0.29	0.6	0.5	2.68	2.68	2.68	2.69
18 9B	86.52	137.67	137.4	51.23	0.27	0.5		2.68		2.69	
19 10A	87.83	139.8	139.51	52.05	0.29	0.6	0.6	2.68	2.68	2.69	2.68
20 10B	87.62	139.56	139.27	52.02	0.29	0.6		2.68		2.68	
21 11A	86.77	138.53	138.2	51.84	0.33	0.6	0.6	2.67	2.67	2.67	2.67
22 11B	86.76	138.51	138.2	51.83	0.31	0.6		2.67		2.67	
23 R12A	87.51	139.31	139.04	51.88	0.27	0.5	0.5	2.68	2.68	2.69	2.68
24 R12B	87.74	139.8	139.52	52.14	0.28	0.5		2.68		2.68	